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(54) Improvements relating to centrifuges

(57) Associated with each rotor of a set of interchangeable rotors of a centrifuge is a memory means adapted at each use of the rotor to memorise data relative to the use. Each rotor has an identification means, and the apparatus comprises electronic management means arranged to receive data relative to the use of a rotor and establish a state of rotor fatigue. The management means is connected or adapted for connection to the memory means for reading and writing to the latter. The fatigue state may be determined in dependence upon number of cycles of use, period of rotation at a given speed, number of 'g' factors experienced in a given period, interval between cleanings.

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FIG. 1

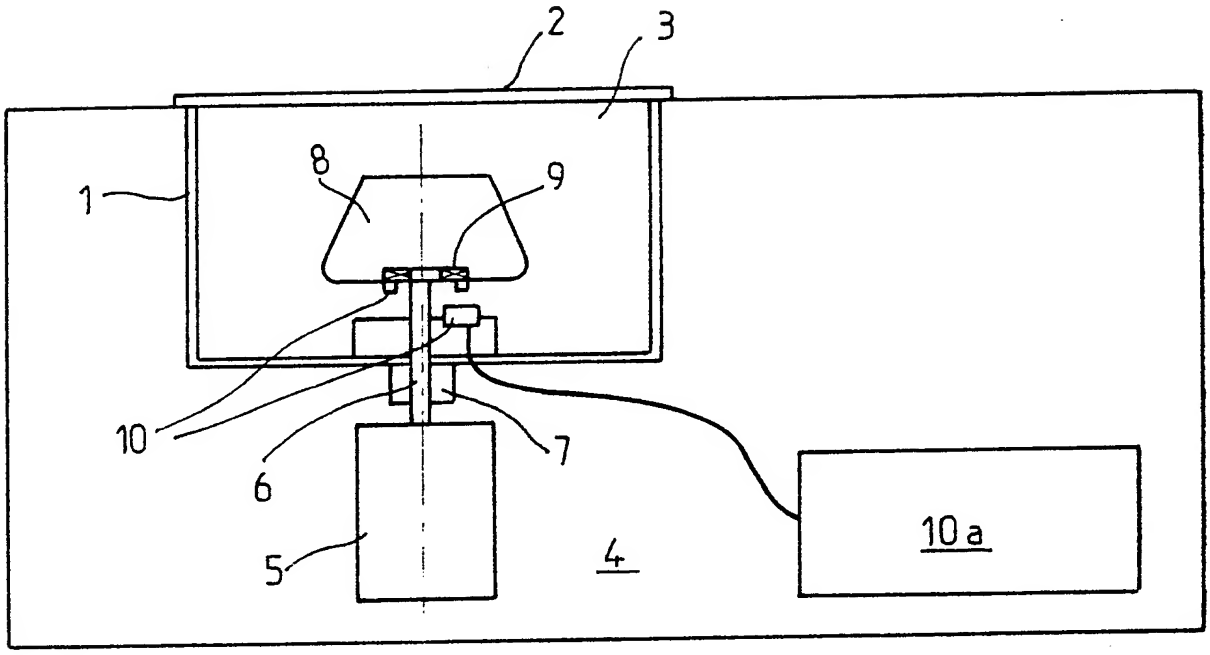


FIG. 2

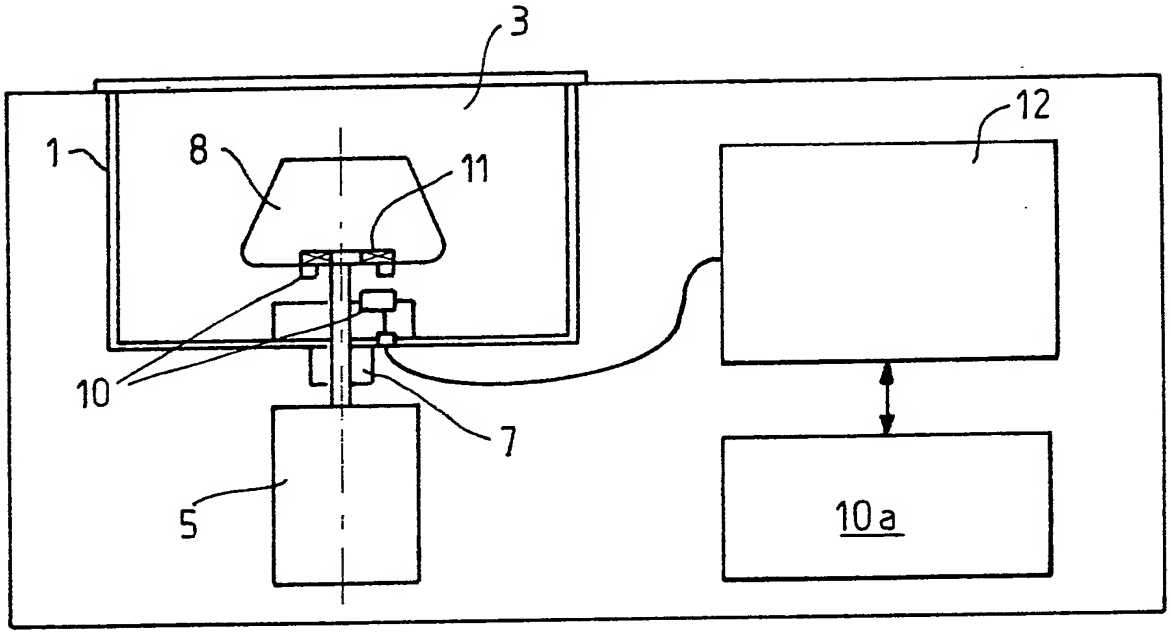


FIG. 3

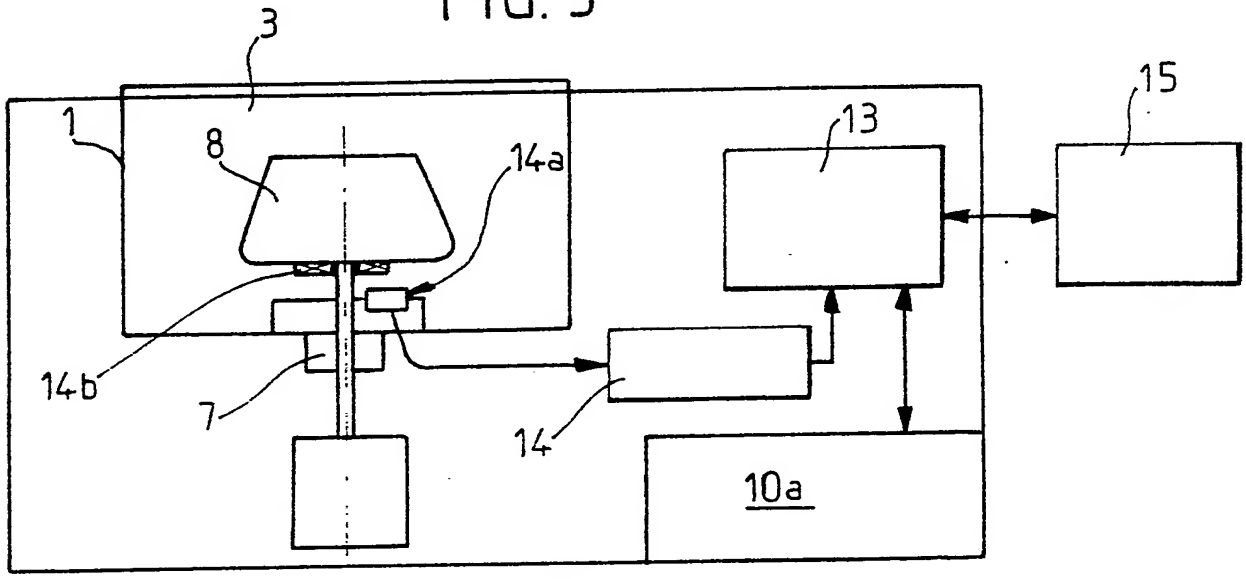


FIG. 4

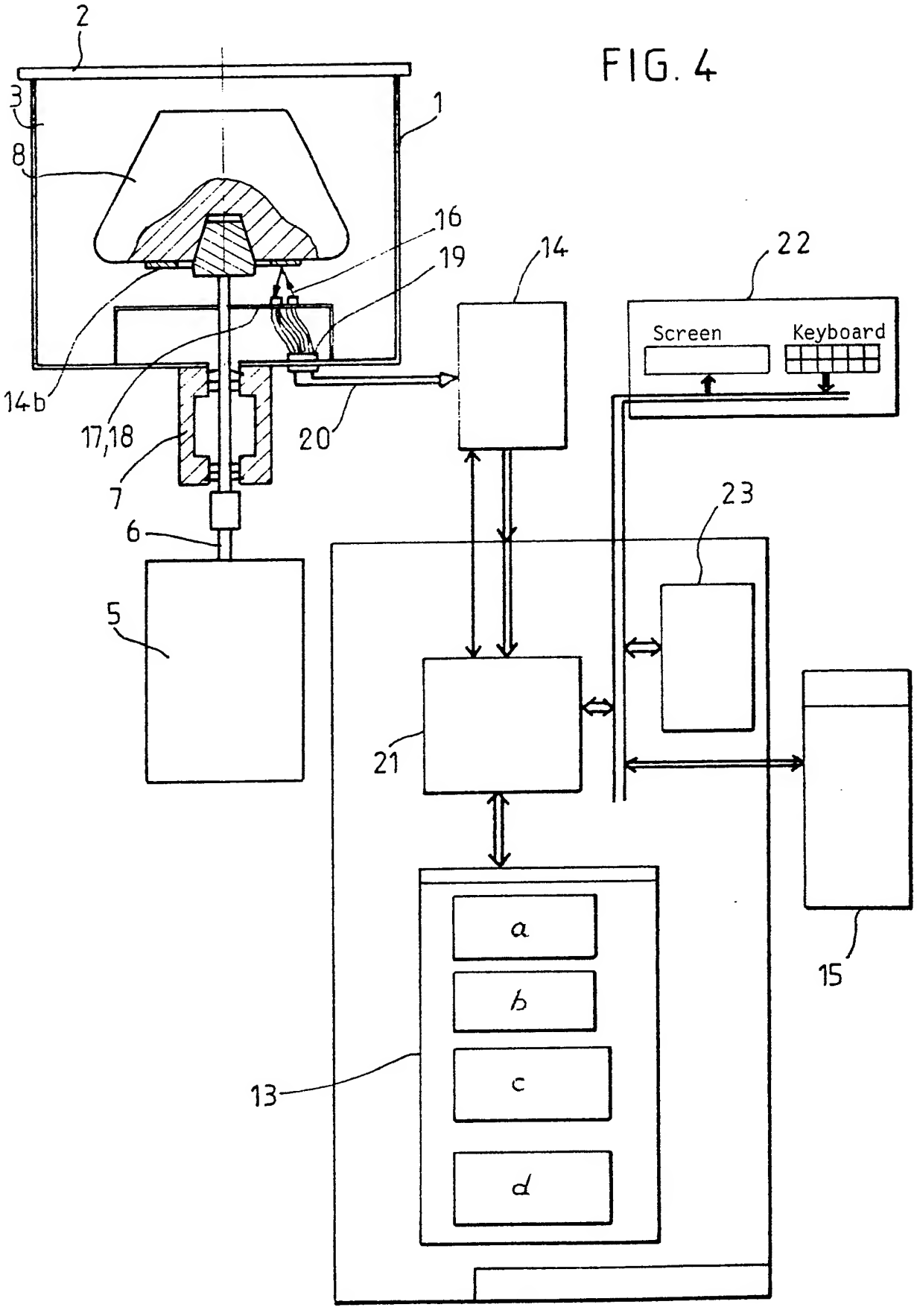
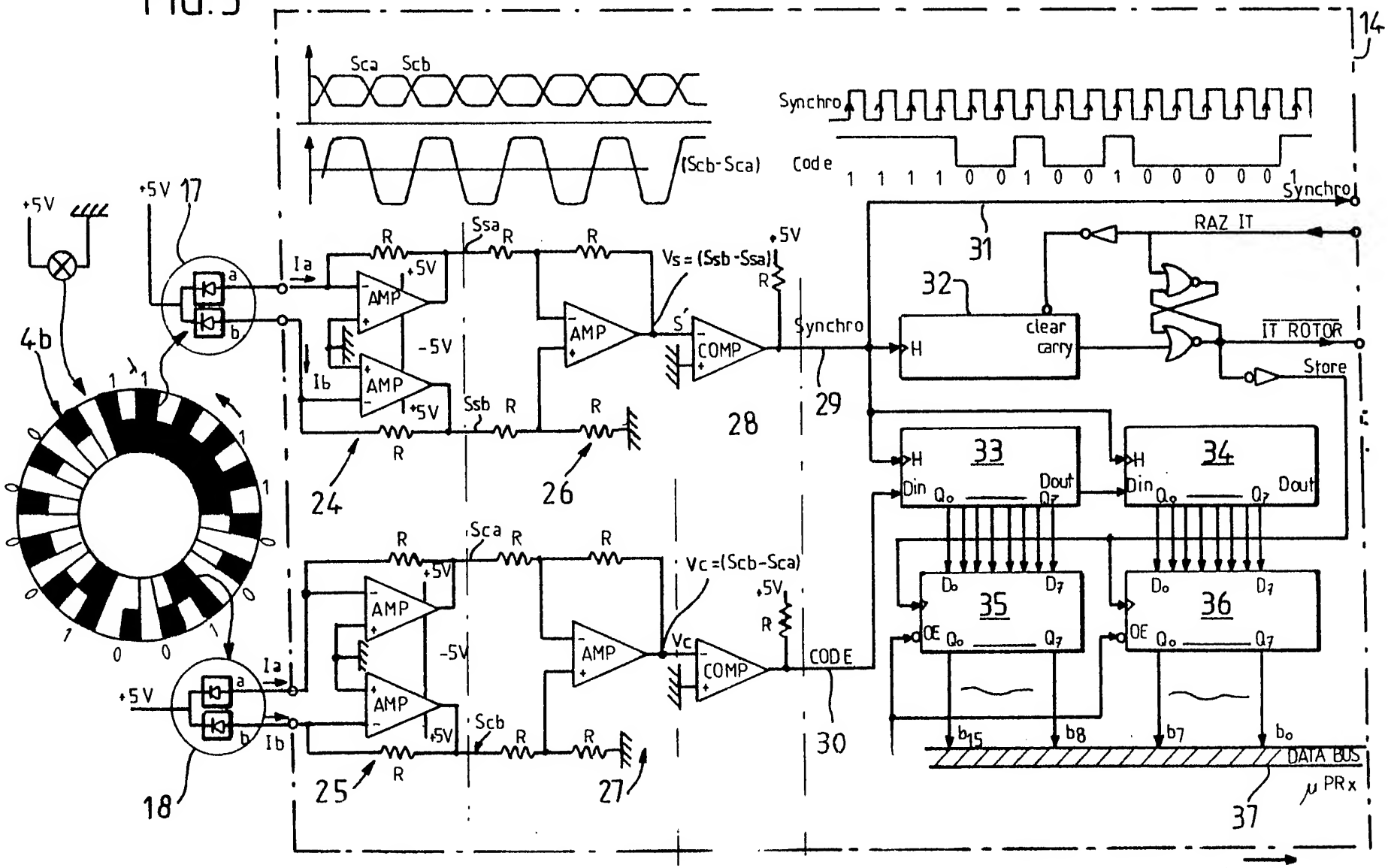

2
3
1
8
16
19
14
22
Screen
Keyboard
14b
17,18
20
7
6
23
5
21
a
b
c
d
13
15

FIG.5


14
Sca Scb
(Scb-Sca)
Synchro
Code
1 1 1 1 0 0 1 0 0 1 0 0 0 0 0 1
+5V
17
4b
18
Ia
Ib
R
Ssa
Ssb
Sca
Scb
AMP
-5V
Vs = (Ssb -Ssa)
Vc = (Scb-Sca)
S'
Vc
COMP
24
25
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29
30
31
32
Synchro
RAZ IT
IT ROTOR
Store
clear carry
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33
34
35
36
Din
Dout
CODE
OE
b15
b8
b7
b0
DATA BUS
μ PRx
37

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Improvement relating to centrifuges

The present invention relates to centrifugal processing apparatus, centrifuges or ultra-centrifuges.

One of the main problems experienced in the safety of centrifuging equipment, particularly ultra-centrifuges, at extremely high speeds of rotation, is that of managing the physical condition of the rotors. Firstly, the rotors of these apparatuses are removable so that one and the same unit may be fitted with different rotors. These rotors may be of different types so that by their very design, their inherent characteristics including their mechanical strength may differ from one type to the other, which makes it necessary to bear this in mind when programming a centrifuging operation and particularly when determining the maximum viable speed. More or less automatic solutions already exist which are bound up with the recognition of a type of rotor, for example by measurement of its inertia, or by the scanning of a corresponding code.

However, the main problem is that of rotors which belong to one and the same type but which have varying degrees of fatigue, the extent of which depends not only on their actual structure, for example the nature of the material of which the rotor consists, but also their past use and particularly but not exclusively the number of centrifugation cycles which they have undergone (one cycle corresponds to one acceleration, maintenance at a rotary speed plateau and then a deceleration).

At the recommendation of the builders of the equipment, users note down in notebooks, on tickets or other carriers the various uses of one and the same rotor, an accumulation of these notes making it possible to assess from which moment the rotor can be regarded as unsuitable so that it is either rejected or is henceforth permitted only to rotate at slower speeds. Of course, this manual procedure is more or less well applied by the users and errors are frequent, even in all good faith. Well, rotor management errors may result in the rotor bursting during a centrifugal process resulting in deterioration not only of the rotor but of the centrifuge itself and the loss of the substance being processed which, in certain cases, may only have been available in a very small quantity after months or years of work.

Consequently, there is frequently associated with centrifuges a printer which keeps a record of the functioning of each rotor, the identity of the rotor being acquired either manually or as for example in the case of the apparatus described in US-A-4.772.254, by a code fixed on the rotor, for example a code constituted by permanent magnets, expressing the individual identity of the rotor, and possibly its type, and read by a suitable pick-up which instructs the printer.

Such devices do not however exclude the possibility of errors both in connection with the acquisition and the exploitation of the rotors and consequently the invention sets out to improve centrifuges and in particular ultra-centrifuges, in order further to reduce or even almost entirely eliminate the risks involved in rotor management.

Another objective of the invention is to be able individually to follow the evolution of a rotor which is likely to be used on different machines.

Yet another object of the invention is to improve centrifuges in such a way as to prevent a centrifuge starting up or to limit it speed if the rotor is suffering from fatigue.

Yet another object of the invention is to make it possible automatically to take into account a number of parameters which influence the fatigue of the rotor so that its degree of fatigue can be more accurately assessed.

Yet another object of the invention is to improve centrifuges and ultra-centrifuges in order to prevent users knowingly going beyond the safety limits.

An object of the invention is an improvement relating to centrifuges and particularly to ultra-centrifuges having removable rotors which are capable of accommodating different rotors of at least one rotor type, the said rotors comprising individual rotor identification means, the centrifugation apparatus comprising electronic means to control rotation of the rotor and which are preferably sensitive to data emanating from the rotor in order to authorise or prevent rotation of the rotor or limit the speed of rotation, characterised in that associated with each rotor is a memory means of an electronic or electromagnetic type, capable at each use of the rotor of memorising data relative to the use, the apparatus comprising electronic management means adapted to receive data relative to the use of the rotor and to transmit data relative to the fatigue condition of the rotor, the said management means being connected to or being adapted for connection to the memory means associated with the rotor in order to read and write into the said memory means.

In a first embodiment of the invention, the memory means is fixed physically on or in the rotor.

In a first alternative form of embodiment, the management means may likewise by fixed physically on the rotor, each rotor being thus associated with a management means peculiar to it, coupling means then being disposed between the rotor and the fixed part of the apparatus for the transfer of data or control signals from or to the management means.

In this case, the management means may be physically associated with the memory means, for example in the form of a single electronic element such as a printed circuit board.

In a second alternative form of this first embodiment, the management means may be permanently mounted on the fixed part of the apparatus, coupling means then being provided to allow the management means to read data contained in the memory means and also in the opposite direction, new data concerning the use of the associated rotor being written into the memory means.

In this alternative embodiment, a management means is associated with each fixed part of the apparatus but it might also be possible to conceive a single separable management means in the form of an electronic card or some other entity, capable of being used in turn on a plurality of centrifuges.

In a second form of embodiment, the memory means is physically separated from the rotor and takes the form of an element such as for example an electronic card, preferably protected against unauthorised recordings, the apparatus then comprising for example plug-in receiving means, such as a card reader or other interface for the memory means associated with the rotor, electronically connected to the management means disposed on the fixed part of the apparatus, the rotor then having individual identification means which may be of any per se known

type, for example optical, magnetic or electromagnetic, the fixed part of the apparatus preferably comprising means sensitive to the identification means in order to identify the rotor and transmit the identification data to the management means. This latter is then advantageously adapted to verify, prior to functioning, agreement of the rotor identities emanating from the rotor on the one hand and from, on the other, the memory means associated with the rotor.

The memory means may for example comprise a memory of non-volatile writing/reading type which can be electrically erased. Such a memory may in the second form of embodiment in particular, be incorporated into a card of the "chip" type, capable of being read and written by the management means when inserted into a suitable receiving member such as a card reader, preferably fixed on the fixed part of the apparatus. This chip card comprises the identity of one and only one rotor.

The management means is preferably articulated about a microprocessor and it has connections for reading and writing on the memory means and also connections to the means of controlling rotation of the rotor and, generally, of controlling the apparatus. Alternatively, the management means may be an integral part of the apparatus control means which may then for example be articulated about a common microprocessor.

Particularly in the case where the memory means consists of a card which is physically separate from the rotor, the identification means carried by the rotor may be of any known type, preferably in the form of a cyclic code with a monitoring of the code weight. The term "cyclic code" is intended to mean a code which is in varying at a circular permutation to the left or right.

Within the meaning of the present invention, the idea of data written by the management means into the memory means of the rotor should be understood to mean data relative to at least one and preferably a plurality of data acquired, picked up or calculated and relating to the use in progress and linked to the increase in fatigue of the material used for the rotor, the said data being capable of being either written and memorised in the memory means in cumulative fashion in order, when read, to provide data concerning the cumulative fatigue state of the rotor or in contrast, in detailed fashion but such that adding the totality of data relative to rotor fatigue may be accomplished by the management means in order to obtain an assessment of the true fatigue state of the rotor.

The data in question preferably refers to at least one of the following parameters:

- number of cycles performed, each cycle increasing this number by one value;
- period of rotation of the rotor at a given speed;
- number of factors g (acceleration suffered by the rotor) enduring for a certain period;
- number of cleanings and/or interval of time between two cleanings;
- imbalance suffered for a certain period.

Other parameters may likewise be used, it being understood that it is preferable to attribute a determining influence to the number of cycles accomplished.

The apparatus according to the invention comprises, either at the level of the management means or at the level of the everyday control means appropriate to the fixed part of the apparatus, conventional manual and/or automatic acquisition means employing a pick-up or detector of the pertinent parameter(s) and particularly

speed of rotation, temperature, pressure, a clock permitting of integration when necessary.

In the form of embodiment in which the rotor has an identification element adapted to be read by a pick-up on the fixed part of the apparatus, it is preferable for identification to be of a visual nature, preferably in the form of a binary code carried by an optical track marked on the rotor. This code is preferably cyclic, that is to say it has no code commencement or code termination data. Monitoring the weight of the code is advantageously envisaged in order to minimise the risks of reading errors. The code may also be applied in the form of a succession of magnets orientated to the south or north. However, any other coding means may be used, provided that it is easy to read from the fixed part of the apparatus and with a minimal risk of error.

Further advantages and characteristic features of the invention will become apparent from reading the ensuing description which is given by way of non-limitative example, reference being made therein to the accompanying drawings, in which:

Fig.1 is a diagrammatic view of an apparatus according to a first embodiment of the invention;

Fig.2 diagrammatically shows an alternative form of this first embodiment;

Fig.3 is a diagrammatic view of an apparatus according to a second embodiment of the invention;

Fig.4 is a circuit diagram of the memory means and management means of the apparatus according to the invention, and

Fig.5 is a circuit diagram of coupling, processing and rotor identification means.

Referring now to Fig. 1, this shows a centrifuge according to the invention, in this case an ultra-centrifuge which is shown diagrammatically. Inside a

protective cover 1 on which there is a lid 2, the apparatus comprises an enclosure 3 in which it is possible to establish a vacuum by conventional means (not shown). Under the enclosure 3 is a drive and control compartment 4 in which there is a driving unit 5, for example an electric motor. This motor causes rotation of a vertical shaft 6 which in sealing-tight manner passes through a bearing 7 to enter the enclosure 3. It is possible removably to mount on this shaft 6 a centrifugation rotor 8 provided with pockets to accommodate tubes containing the samples to be centrifuged, and the construction of which is entirely conventional.

Fixed on the rotor 8, preferably in a sealing-tight casing, is an electronic assembly 9 comprising a memory module and a management module. The memory module mainly comprises a memory of the non-volatile type and conventional means associated with the memory. The size of the memory may for example be around 2 x 1 x 0.4 (cm).

The electronic assembly 9 likewise comprises a management module articulated about a microprocessor or other integrated circuit. The microprocessor is adapted to administer the writing and reading of data into and from the memory in the memory module. Furthermore, the microprocessor executes a programme contained in an associated memory in order to calculate a so-called fatigue state by, thanks to an algorithm appropriate to this programme, integrating the various items of data transmitted to it at each use of the rotor in a centrifuging apparatus, on condition that such data is individually stored in the memory module. This fatigue state may if applicable be stored and kept up-to-date in the memory module or completely recalculated whenever it is necessary. Alternatively, the memory module may store only the figure state, detailed data concerning each use of the rotor not being retained.

However, it is preferably to provide a supplementary memory means other than that carried by the rotor and mounted in the fixed part of the centrifuge and in which all the data contained in the memory means associated with the rotor are duplicated at each use of the rotor in the centrifuge, which makes it possible to restore the data in the event of damage to the means associated with the rotor.

Possibly, the electronic assembly may also carry a rotor identification signal in a memory which may be that of the memory module.

The electronic assembly also has coupling means 10, for example electromagnetic or capacitative coupling means carried by the under side of the rotor and a fixed position situated opposite and connected to the electronic means 10a of the fixed apparatus, generally articulated about a microprocessor. Coupling means of this type are well known and have no need to be detailed here. Preferably, they are arranged in a known manner so that coupling takes place during rotation of the rotor. Thus, the coupling means on the one hand permit transfer of energy to the electronic means of the rotor in order to supply these latter with energy and the said electronic means can then advantageously comprise electrical energy storage means, an accumulator or a capacitor. Furthermore, they permit of transfer between the fixed part and the moving part constituted by the rotor, while the instructions and data which make it possible from the fixed apparatus, for example to read the contents of the memory module or to interrogate the management module to acquire information concerning the fatigue state of the rotor. In the opposite direction, it is possible by this coupling means to address to the management module on board the rotor data concerning the use of the rotor such

as the number of cycles, speed of rotation multiplied by the corresponding periods of time, number of cleanings, integrated value of the imbalance detected, etc., these various items of information being taken into the algorithm by the microprocessor of the management module to calculate the rotor fatigue condition. Furthermore, according to a particularly interesting improvement, the fixed control means on the fixed part of the centrifuging apparatus may be arranged so that upon the commencement of a cycle they interrogate the management module concerning the fatigue state of the rotor and if this state exceeds a predetermined threshold, to prevent rotation or to permit only of a lower limit speed.

Reference will now be made to Fig. 2.

Fig. 2 shows an apparatus similar to that in Fig. 1 but in which the rotor 8 carries only one memory module 11 in a sealing-tight casing, this memory module being associated with coupling means on the rotor for a transfer coupling of data to the fixed part of the apparatus. On the fixed part of the apparatus is an electronic management module 12 fixed permanently on the apparatus and in a functional relationship with the operating means 10a of the apparatus. The management module is able to communicate with the memory module thanks to previously mentioned coupling means 10. From a functional point of view, the management module 12 comprises the same elements and carries out the same functions as in the previously described case. Furthermore, the management module is arranged to read into the memory module 11 an item of data memorised permanently and in unalterable fashion concerning the identity of the rotor 8 in question.

However, in the embodiments shown in Figs. 1 and 2, it is likewise possible physically to affix to the rotor a rotor identification employing a suitable code, the fixed

part of the apparatus comprising reading means which make it possible to read the identity of the rotor.

Reference will now be made to Fig. 3.

In this embodiment, the fixed part of the apparatus comprises a management module 13 which is not connected to coupling means for the transmission of signals or data from or to the rotor. As in the previous cases, the module 13 is preferably linked functionally to the electronic means 10a of controlling and running the apparatus.

An identification module 14 is likewise disposed on the fixed part, this module being fitted with a pick-up 14a or other device which makes it possible to identify the rotor which to this end carries an identify in coded form 14b capable of being read by the means in module 14.

The fixed part of the apparatus further comprises a plug-in element (not shown), such as a printed circuit board reader into which it is possible to plug a memory module 15 which takes for example the form of a chip card, preferably protected against unlawful attempts at input. The module 15 is associated with the rotor and in its memory it carries in a non-erasable manner the same identity number as that provided by the physical code 14b of the rotor. Consequently, if a set of rotors is available, each rotor is associated with a separate memory module 15 which is peculiar to it and which is physically detached from the motor. The management module 13 is connected to the plug-in means in such a way that it is possible to read the data contained in the module 15 and likewise address to the module 15 the memorised data concerning the present functioning of the rotor 8.

The programme of the management module 13 is so adapted that prior to a centrifugal treatment cycle, at the onset thereof, it verifies concordance of the rotor

identify signal which reaches it from the module 14 which has read the identify of the rotor and the data which comes to it from the memory module 15. In case of coincidence, it allows the functioning or the continued functioning of the centrifugal process. In the event of disagreement, it advantageously prevents continuance of the cycle.

The code which is affixed physically to the rotor to permit of its identification may advantageously be of the optical type, but it is likewise possible to envisage having a magnetic code or any other kind of code. In the case of a visual code, it may advantageously be disposed either on the under side of the rotor or on its periphery, for example in the form of a circular visual track or a plurality of concentric tracks provided with visually different segments, for example for a binary code.

However, it would also be possible to provide solely a visual inscription of identity on the rotor, in which case the operator would then feed in this identity manually by the keyboard of the centrifuge, the management means controlling coincidence of the identity on the memory card 15 with the identity fed in at the keyboard.

A general diagram of the embodiment corresponding to Fig. 3 is shown in Fig. 4 and also in Fig. 5.

It can be seen that the physical code 14b situated on the rotor 8 is provided for example by means of a visual disc which carries two concentric tracks, the first, the peripheral track, comprising 16 segments shown in black, 16 non-reflective segments shown light, the second, the inner track, comprising opposite the reflective segments of the peripheral track either black segments or light segments in order to constitute a cyclic code which represents the identity of the rotor. The peripheral track is used as a means of synchronising reading on the

angular position of the reflective segments representing the code.

The detection means 14a comprises a visual emitter 16 and two visual receivers constituted by respective double photodiodes 17, 18, the first 17 being sensitive to the light reflected from the peripheral track and the other, 18, to that reflected from the inner track which carries the rotor identity code. Through the plug-in connector 19, the detected signals are transmitted via an electrical connection 20, to the rotor identification module 14 connected to the microprocessor 21 which is itself functionally connected to a panel 22 on the centrifuge, comprising a screen and a control keyboard, with a memory module 23 in which it is possible from the keyboard to store pertinent data in respect of the rotor and relative to the centrifugation operation which has to be carried out, such as in particular the loading on the rotor and by means of a card reader (not shown), with the memory card 15 which contains the identification code of the rotor corresponding to the code carried by the internal visual track, the data associated with the rotor and relating to its constitution, the results of ageing calculations, and data concerning the operation of the rotor. The microprocessor is likewise functionally connected to the management unit 13 which takes the form of a programmable memory containing the programme a for processing visual signals representing the coupling of the rotor, the rotor identification programme b, the rotor ageing determination programme c and which may likewise be used to contain a centrifuge running and monitoring programme d.

The module 14 is shown in greater detail in Fig. 5 and for each double photodiode 17, 18, it receives by differential connection a first current-voltage conversion stage 24, 25 followed by a second differential amplifier

stage 26, 27 the output from which leads to a comparator stage 28 for shaping signals. The output 29 from the path originating from the pick-up 17 when the rotor is rotating addresses synchronising pulses corresponding to the alternating passages through light and dark segments before the pick-up (a synchrosignal on the drawing) while the output 30 addresses code signals (code curve on the drawing) corresponding to reading of the inner visual track. The synchronisation signals emanating from the path 29 are on the one hand addressed to the microprocessor via a path 31 and on the other sent to a 4-bit binary counter 32 and finally addressed simultaneously to a 16-bit shift register constituted by two 8-bit shift registers 33, 34 to ensure synchronous shift of the bits of the codes 30 in the said register. The output from the counter 32 at each 16th synchronising pulse, addresses a signal to two storage registers 35, 36 which are themselves functionally linked to a data bus 37 feeding the microprocessor.

With effect from the moment when the counter 32 has emitted an output pulse, the rotor code is entirely contained in the registers 33, 34 and immediately transferred by means of the STORE signal to interface registers 35, 36 which are linked to the bus of the microprocessor which reads them whenever it has been warned by the signal IT ROTOR.

According to the directives of its programme, the microprocessor performs a comparison of the rotor code read from the visual disc with the identity code stored in the chip card 15. As it is a cyclic visual code which has no marking of the start and finish, the code which has arrived in the elements 35, 36 and which is compared with the code on the card is in fact a random circular permutation of the card code and the microprocessor is

programmed in order to restore concordance. Once this is noted, that is to say when the rotor code read on the visual disc coincides with the code contained in the card 15, the microprocessor reads the instructions relative to the centrifugation operation which is programmed, seeks in the memory card 15 information concerning the current ageing condition of the rotor and as a function of conditions which are preset according to an algorithm, authorises or does not authorise centrifuging to proceed. If the codes do not coincide, centrifugation is not authorised.

CLAIMS:

1. A centrifugal processing apparatus, centrifuge or ultra-centrifuge having a removable rotor, the apparatus being adapted to operate with different rotors of at least one type and each of said rotors comprising individual rotor identification means, characterised in that associated with each rotor (8) is a memory means (9, 11, 15) capable at each use of the rotor of memorising data relative to the use, and the apparatus comprises electronic management means (9, 12, 13) arranged to receive data concerning the use of the rotor and to transmit data relative to the fatigue condition of the rotor, said management means being connected or adapted to be connected to the memory means associated with the rotor (8) in order to write and read data into the said memory means.

2. An apparatus according to Claim 1, characterised in that the memory means (9, 11) is physically fixed on or in the rotor.

3. An apparatus according to Claim 2, characterised in that the management means (9) is likewise fixed on the rotor, coupling means (10) being provided between the rotor and the fixed part of the apparatus for the transfer of data signals or commands from or to the management means (10).

4. An apparatus according to Claim 3, characterised in that the management means and the memory means are associated in the form of a single electronic element (9) such as a printed circuit board.

5. An apparatus according to Claim 2, characterised in that the management means (10) is mounted on the fixed part of the apparatus, coupling means being provided to allow the management means to read the data contained in

the memory means (11) and conversely for new data concerning the use of the associated rotor (8) to be recorded in the memory means.

6. An apparatus according to claim 1, characterised in that the memory means (15) is physically separated from the rotor, the apparatus comprising receiving means which make it possible to connect the memory means (15) to a management means (13) fixed on the fixed part of the apparatus, the rotor carrying means (14b) of identifying its identity.

7. An apparatus according to claim 5, characterised in that the memory means takes the form of a card which can be plugged into a reader or an interface carried by the apparatus.

8. An apparatus according to one of claims 5 or 6, characterised in that the rotor carries a code or individual identity symbol adapted to be read by identification means carried by the fixed part of the apparatus and transmit identification data to the management means (13).

9. An apparatus according to any one of claims 1 to 8, characterised in that the management means (9, 12, 13) is arranged to determine, according to an algorithm, an assessment of the fatigue state of the rotor, taking into account at least one of the following parameters:

- number of cycles performed;
- period of rotation of the rotor at a given speed;
- number of factors g undergone over a certain period;
- number of cleanings and/or interval of time between two cleanings.

10. An apparatus according to any one of claims 1 to 9, characterised in that the management means is arranged to read into the memory means data connected with each use of the rotor.

11. An apparatus according to any one of claims 1 to 10, characterised in that the management means is arranged to record into the memory means data corresponding to the fatigue state calculated by the management means.

12. An apparatus according to any one of claims 1 to 11, characterised in that the fixed part of the apparatus comprises preferably at the level of the management means if this is carried by the fixed part of the apparatus, a memory means in which are faithfully duplicated all the data contained in the memory means associated with the rotor, so that in the case of accidental loss of the data contained in the memory means associated with the rotor, it is possible to restore the lost data.

13. An apparatus according to any one of claims 1 to 12, characterised in that the rotor comprises as visual code (14b) coding for its identity and co-operating with a fixed pick-up means (14a) connected to a module administering the rotor identity signals (14).

14. An apparatus according to claim 13, characterised in that the visual code comprises a track carrying a cyclic code with which a synchronising track is associated.

15. A centrifugal processing apparatus, centrifuge or ultra-centrifuge constructed, arranged and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

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ABSTRACT:

CHG DATE=19940730 STATUS=O> Associated with each rotor of a set of interchangeable rotors of a centrifuge is a memory means adapted at each use of the rotor to memorise data relative to the use. Each rotor has an identification means, and the apparatus comprises electronic management means arranged to receive data relative to the use of a rotor and establish a state of rotor fatigue. The management means is connected or adapted for connection to the memory means for reading and writing to the latter. The fatigue state may be determined in dependence upon number of cycles of use, period of rotation at a given speed, number of 'g' factors experienced in a given period, interval between cleanings.